Rapid Prototype Fabrication of Composite Structures and Joining Methods

Project Number: 96-02

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Purpose

The purpose of this research project is to search for innovative techniques for the rapid production of cost-effective composite structures that have a tentative design. Fastening techniques for composites are a secondary issue if time allows. Great focus is placed with the actual hands-on production of the composite structures to test new innovative concepts for future hardware feasibility. The intent is to take manufacturing risks that will greatly broaden our experience base.

Background

The use of composites is the fastest growing segment of the plastics industry. The need for stronger and lighter weight structures is increasing in the aerospace industry as well as the commercial sector (sporting goods, medical, and transportation etc.). Aerospace companies and government agencies are being encouraged to seek out more cost-effective methods for producing hardware. Small composite manufacturing companies tend to be innovative with the manufacturing techniques that they develop. The fabrication of composites, in some cases, is an art as much as it is a science. There are cases where the technique that is used could overshadow the design. Tooling for the fabrication can be rather expensive, and errors in the design of composite hardware can prove to be very costly. Composite prototypes of structures can be very useful in the conceptual phase of design and they can uncover various unforeseen manufacturing problems. Composite materials are often viewed as a material substitute for metals, and designs tend to overlook fastening issues. These are the reasons that this research is valuable.

Approach

The approach to meet the objectives of this research begins with an outreach to private industry and material suppliers for fabrication methods that are innovative and cost effective. An inquiry is done to predict the type of hardware that may be required from future programs. The methods that are used by traditionally non-aerospace companies are evaluated for possible modification to meet aerospace needs. Composite prototypes are then produced by alternate techniques to test for viability and producibility.

Accomplishments

- Low-cost tooling methods have been utilized for the production of composite lines and ducts. High-density urethane foam and a flexible metallic duct have proven to be useful in the production of composite piping with a rather complex geometry. The urethane components are cast in a composite mold and then later assembled to the desired geometry. The flexible metallic duct is bent to the desired configuration; the surface ridges are then filled.

- Urethane foam and wood have both been used to produce other components; master shapes for the production of lightweight composite tooling that is dimensionally stable for the cure cycle of composite hardware.

- Epoxy resin formulations were developed to use with a dry fabric in a simple device for prepregging material that is staged with the introduction of UV light. This was an effort

to speed the production of commercially available materials without waiting on a special production run from a supplier.

- Braided fibers (as sleeves) were utilized for the production of composite ducts along with expandable mandrels. The dry braiding is placed over the mandrel and a filmed epoxy resin is alternated with the layers of the braid.

- MSFC's rapid prototyping facility was utilized to evaluate the feasibility of using the plastic prototypes as means of making a mandrel that can produce composite models and tooling for composite hardware.

Planned Future Work

- The investigation of cheap, lightweight mandrels for the production of composite pressure vessels will be reconsidered.

- The use of thermoplastic materials as a matrix for composites will be compared to epoxies for the production of small diameter tubes.

- A prototype mirror structure will be produced out of dimensionally stable composites and then coated with a metallic film. A composite overwrap to support replicated optical mirrors will also be evaluated.

- A plastic foam that expands near the cure temperature of epoxy resins will be further evaluated for the production of small composite parts.

Publications and Patent Applications

A patent is being pursued for the techniques in the production of a composite softball bat. A paper will be presented at the '98 SAMPE (Society for the Advancement of Materials and Process Engineering) symposium and exhibition in Anaheim, CA. The topic will be, "The Use of Low Cost Tooling Foam for the Production of Composite Structures."

Funding Summary ($k)

95k was authorized by letter (45k for FY96, 50k for FY97).

All is obligated.

Status of Investigation

Project approved—October 1995

Estimated completion—June 1998

The effort in 1998 could go further for about 25k.

A small amount of funding would be advantageous for obtaining some materials that were discovered recently (~ 10k).